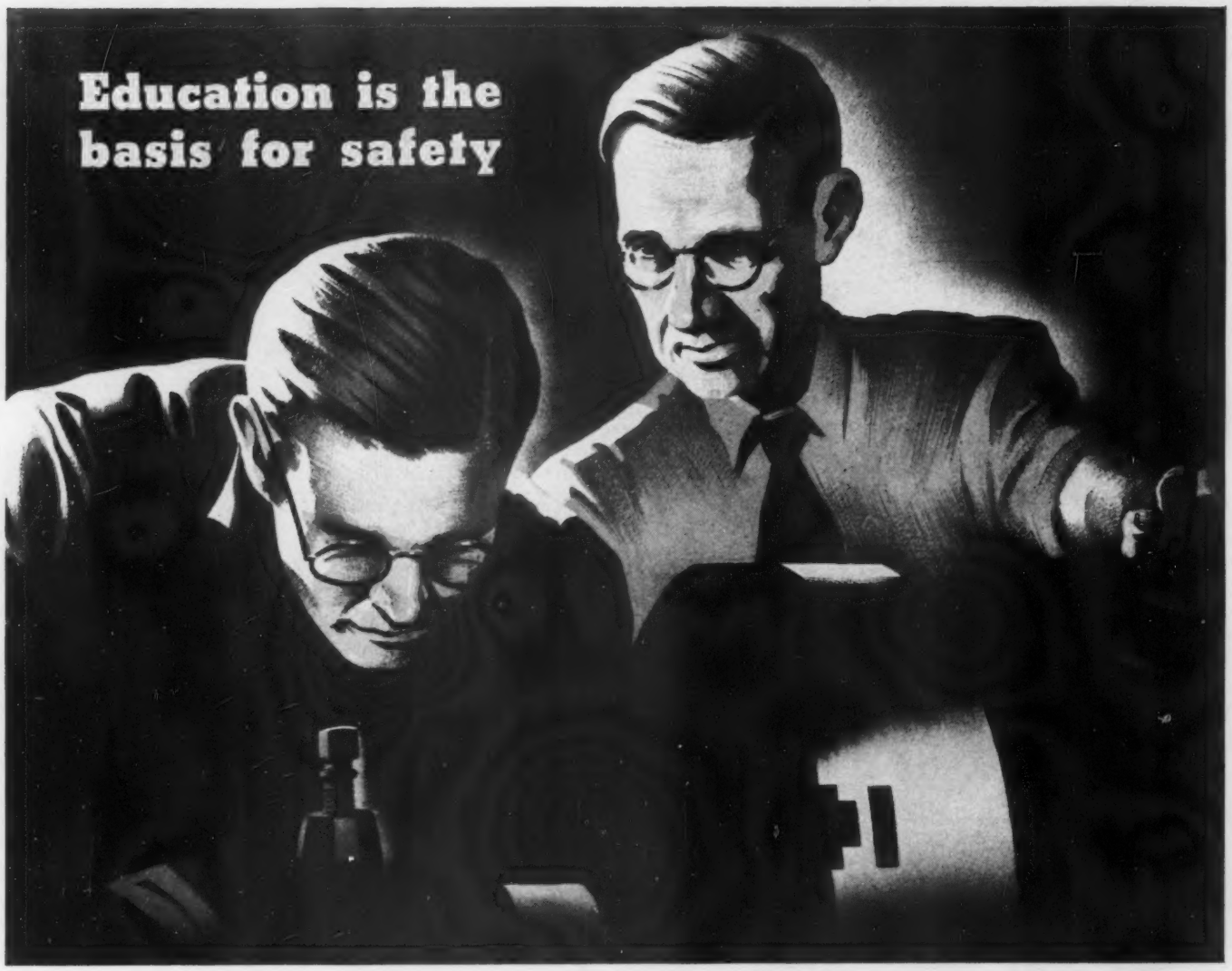
TECH ENGINEERING NEWS
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

JANUARY • 1943

WOOD BOATS FOR WAR USES

SEE PAGE 31



Information supplied by the National Safety Council

Labor, particularly inexperienced labor, cannot be expected to recognize the full penalties of carelessness in the shop. Management has assumed the responsibility of supervising safety measures, and has cooperated in establishing sound safety rules.

Nevertheless, the large increase in labor personnel due to war needs, plus the influx of inexperienced men, have resulted in a substantial increase in lost time accidents.

Even assuming that the obvious safety measures with regard to operating machinery, electrical equipment and shop traffic have been installed, two factors — education and eternal vigilance — determine the real effectiveness of any safety program.

Both are the responsibility of the supervisory staff, from foremen up. The foreman who does a thorough job of educating his particular group in safety rules and cooperative enforcement has done much to cut down accidents. Management that takes an active interest in both safety education and the enforcement of safety measures has taken a great step forward in reducing wastage of irreplaceable production time.

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WE SALUTE DR. ASHCRAFT and the other thousands of scientists who are working for victory in research laboratories all over America.

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TOM THUMB CHEMISTRY . . . Dr. E. Bruce Ashcraft examines a specimen weighing less than a microgram . . . approximately 1/50th the size of a grain of ordinary table salt. Dr. Ashcraft received his B.S. at Texas A & M, and his Ph.D. at Cornell University in 1937.

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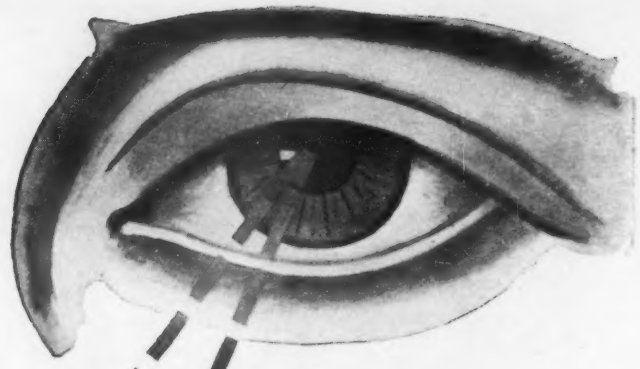

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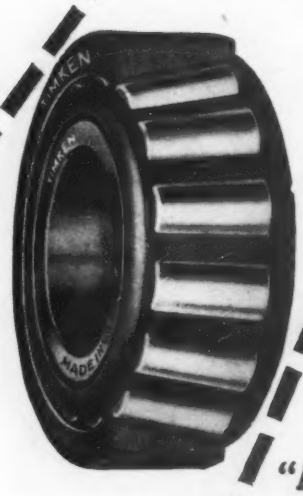

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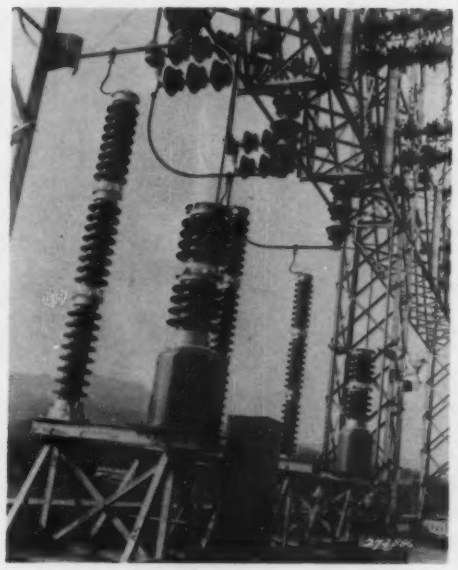
THE TECH ENGINEERING NEWS

JANUARY · 1943



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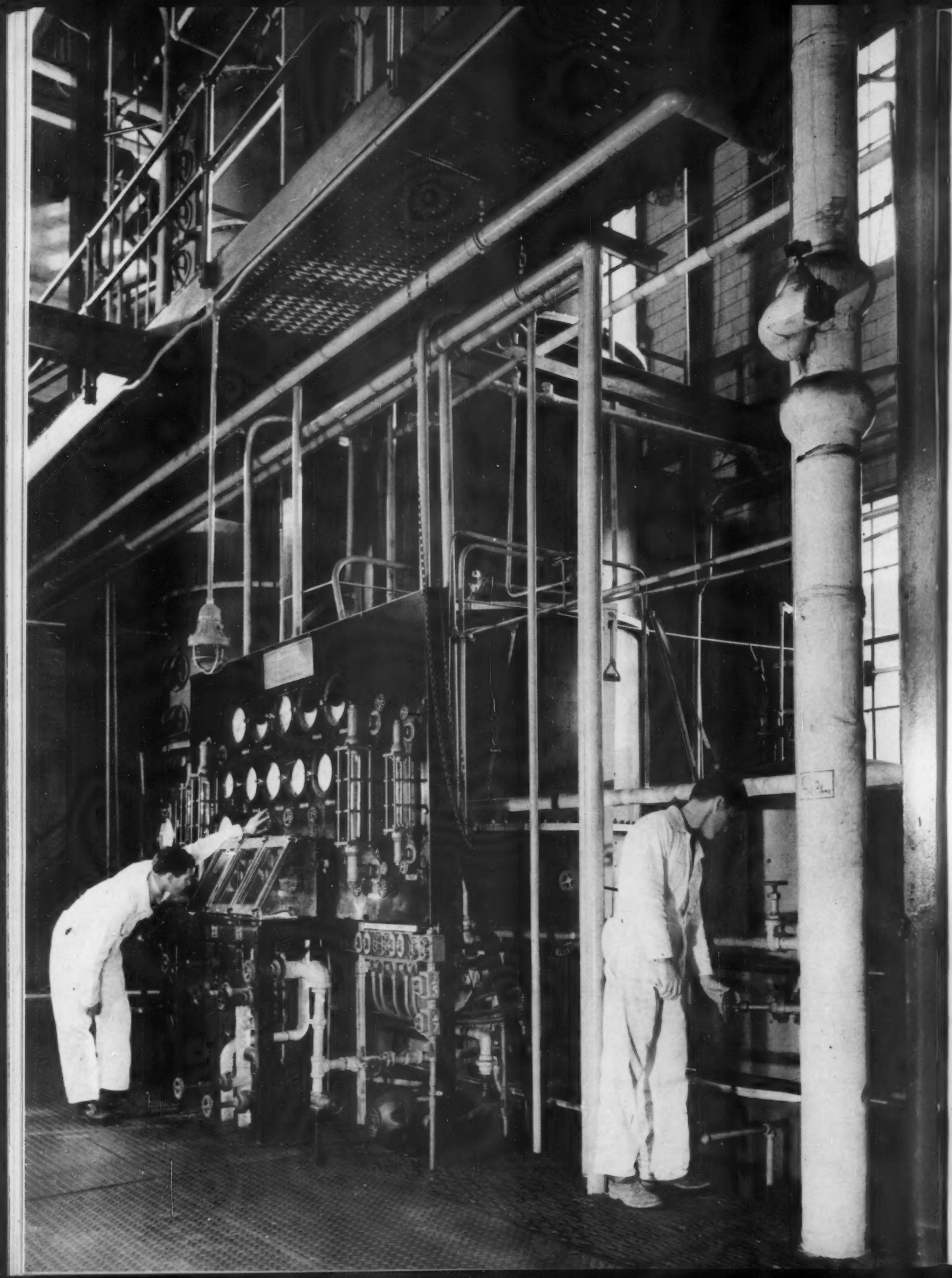


SYNTHETIC RUBBER

OUR PROGRESS TOWARD SELF-SUFFICIENCY WITH AN OPTIMISTIC VIEW OF ALCOHOL AS A RAW MATERIAL

By DR. A. J. LIEBMANN, PH.D.

AT the beginning of the present war, 95 per cent of our rubber requirements came from outside of the United States. No other country in the world used as much rubber as this country. The yearly consumption in tons of crude rubber from 1936 to 1941 was estimated by the Government as follows:

1936.....	575,000	1939.....	592,000
1937.....	543,600	1940.....	648,500
1938.....	437,031	1941.....	750,000

When the war broke out, the total stock pile of crude rubber in this country, in the hands of the Government and private industry, was probably less than 600,000 tons.

The exact requirements of rubber during the war years is, of course, a military secret, but it may readily be assumed that even with the reduction put into effect by the War Production Board (amounting to approximately 25 per cent), the average requirements for the years 1942, 1943 and 1944, for domestic purposes and for lend-lease requirements, will be at least 700,000 tons a year.

The source of natural rubber has been almost entirely the Far East. Ninety-five per cent or more came from there.

Consequently upon the outbreak of the war in the Pacific we found ourselves, with the interruption of this source of supply, in a serious condition.

The United States should not again be confronted with such a condition, and it will be the part of science and industry to make their contribution toward making repetition of such a condition impossible.

The remedy obviously is the provision for rubber within the country itself. True enough, we expect to re-establish trade relations with other nations, after the termination of this war. We will exchange commodities and products. One of these commodities, which we will purchase again, will be rubber, but it is doubtful if in the future as much as 25 per cent of the total requirements will be of this nature.

Science and industry have taken a hand from the moment the rubber shortage became evident, and the industry of synthetic rubber was created with a rapidity which is as commendable and superb, as the lack of foresight in starting it earlier was unbelievable and deserving the criticism it received.

Rubber, natural rubber, was originally found in Brazil. From there it was introduced to the Far East and cultivated there chiefly in the Malayan Peninsula, in Sumatra and some of the other East Indian islands.

When the normal supply of natural rubber suddenly ceased, interest was revived in two plants which show possibilities for cultivation of natural rubber in this country: Kok-sagyz of Russian origin and Guayule of Mexican origin.

Dr. Alfred J. Liebmann was born in Zurich, Switzerland. He graduated from the Federal Polytechnic School there in 1907, where he studied chemical engineering, and received his Ph.D. from the University of Zurich in 1909. Settling permanently in America in 1912, he has held executive positions in both the Independent Lamp and Wire Company and the Elkon Works of General Electric. Since 1933 Dr. Liebmann has been Technical Director of the Schenley Distillers Corporation. A resident of Cincinnati, Ohio, he is a member of the American Chemical Society and the American Electro-Chemical Society.

Agricultural studies were quickly initiated and expanded in order to determine the suitability of American soil for the cultivation of these plants.

Considerable difficulties were encountered in adapting the plants to the western American climatic conditions and it is highly improbable that these two plants can be considered for relief of the critical rubber shortage during the present war period, nor does it appear very likely that their role in the future will be very impressive.

Rubber is chemically a hydrocarbon with the empirical formula $(C_5Hg)_n$ discovered by Faraday as early as 1826.

The real development and importance of the rubber industry dates from the discovery of the vulcanization process by Charles Goodyear in the year 1839.

Attempts toward the production of synthetic substitutes for rubber date back to 1826. Since then a great many synthetic products have been produced, which had properties similar to those of natural rubber, and therefore were claimed by their inventors or producers as artificial or synthetic rubber.

Chemically these "substitutes" vary widely in their composition. They all have, however, certain physical characteristics usually ascribed to, and valuable in natural rubber. Very generally speaking a material, in order to be qualified as "rubber," should stretch readily to quite considerable degree and, after release, retract quickly and forcefully.

Consequently the chief requirements for synthetic rubber are elasticity and strength, but in addition there must be resistance to ordinary oxidation, against deterioration by oils and organic solvents and to extremely high or low temperatures.

It is of particular interest that some of the artificial products surpass the natural in some of these respects.

Synthetic rubber was first produced on a large scale in Germany. During the last war, tires made from synthetic rubber were supposedly used under very favorable conditions for as much as three thousand miles. This figure may appear low, but it must be taken into consideration that the stationary warfare prevailed at

Alcohol stills for production of 190° ethyl alcohol
Schenley Research Institute

that time, and artificial tires permitting operation over a limited mileage were of proportionately much greater value than they would be today.

Since then the development of synthetic rubber industry in Europe has made great strides, so that with the beginning of this present war, Germany was, to a great extent, independent of natural rubber. Russia also had developed its artificial rubber industry to a considerable degree.

The quality of these products was reported high enough to permit the production of tires to withstand, under ordinary conditions, a usage of over twenty thousand miles.

It is characteristic of modern science and ingenuity that such a product is merely regarded as an intermediate step. Based on recent and present developments, it may be assumed with reasonable certainty that within a not too distant future, tires will be produced from synthetic material, which will run on ordinary commercial vehicles for as much as fifty thousand miles.

We have all the resources in the United States to make synthetic rubber, not only from natural gas or from oil or coal, but even without the use of any of these natural resources we will be able to make synthetic rubber entirely from agricultural products, either by way of alcohol and other intermediate steps or directly from vegetable oils, such as, for instance, soy bean oil.

The task of American industry for production of synthetic rubber, during the present emergency, has been clearly set forth in the famous Baruch-Compton-Conant Report, transmitted by the President to the Congress of the United States on September 10, 1942.

The schedule calls for the early production of 886,000 tons, of which 80 per cent will be of the Buna S type.

This Buna S type of rubber is the one perfected in Germany, but it is safe to say that recent developments in this country have not only greatly advanced the production process, but also the end product.

Seven hundred and five thousand tons of this type must be produced per year, and the Baruch Report allots the production to six different procedures, namely:

1. From alcohol, by the Carbide and Carbon chemical process	242,000 tons
2. From natural gas (butane)	50,000 tons
3. From butane by Houdry process	16,500 tons
4. From butylene (obtained by cracking of petroleum), as practiced by Standard Oil Company	283,000 tons
5. By the cracking of other oils and natural gases	20,000 tons
6. From refinery conversion process	113,500 tons
	724,500 tons

To these 705,000 tons of Buna S type will be added butyl rubber to yield 132,000 tons and 49,000 tons of neoprene.

This latter variety, produced by the du Pont company, is a product of very high purity, possessing such desirable qualities as to make it particularly valuable for lining of airplane fuel tanks, so as to render them self-sealing and puncture proof.

The principal types of synthetic rubbers developed during the last few years are outlined here:

A. Simple Butadiene polymers.
  1. Buna 85 — German.
  2. SKA — Russian.

B. Modified Butadiene Co-polymers.
  1. Pernunan — co-polymers with acrylonitrile.
  2. Buna S — co-polymer with styrene.
  3. Buna SS — co-polymer with greater amount of styrene than used in Buna S type.

C. Substituted Butadiene polymers.
  1. Neoprene — chloroprene polymer (du Pont).
  2. Sovprene — chloroprene polymer (Russian).
  3. Methyl rubbers — dimethylbutadiene polymers.

D. Butene polymers.
  1. Butyl rubber — Butene and diolefin polymer.
  2. Oppanol — Isobutene polymer.
  3. Vistanex — Isobutene polymer.

E. Polyvinyl derivatives.
  1. Butvar — Polyvinyl alcohol and butyraldehyde polymer.
  2. Koroseal — Plasticized vinyl chloride polymer.

F. Organic Polysulfides.
  1. Thiokol.
  2. Vulcaplas.
  3. Perduren.

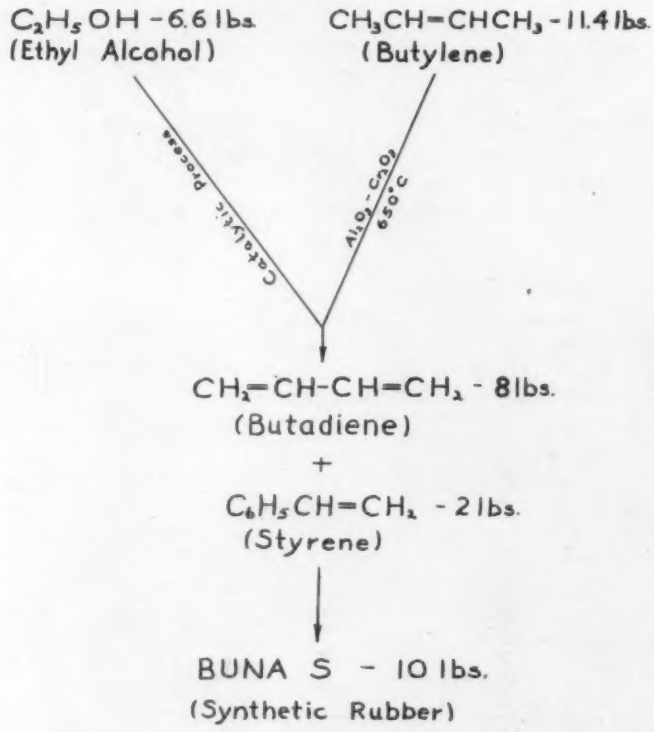
Other processes are still being developed and may be in actual production within the coming year. They will particularly try to utilize farm products.

As stated above, over 80 per cent of the entire synthetic rubber program is for the Buna S type. At first it was contemplated that at least half of the raw material would be derived from the petroleum industry. It now seems probable that perhaps the majority of the raw material will be derived from alcohol. The entire distilling industry of the United States has been mobilized and is now exclusively producing 190-proof alcohol, almost entirely from grain (corn and wheat, with barley malt for conversion), at a yearly rate of over 500,000,000 gallons.

As stated above, the chemical composition of synthetic rubber varies considerably. Obviously the processes differ similarly, and it would be impossible to give a complete description of the chemical conversion.

In the better known processes, the two most important are those from alcohol and from butylene. The chemical transformations taking place are indicated by the following formulae:

Figure 1



WOOD FOR SMALL BOATS

BUILDERS OF WOOD BOATS AND THE LUMBER INDUSTRY HAVE MANY COMMON PROBLEMS

By CARL A. RISHELL

C. A. Rishell, born in Emporium, Pa., is a leading authority on lumber specifications for boats. Mr. Rishell served in the Navy during the first World War, and after the war studied forestry in Pennsylvania State College, from which he was graduated in 1923. After leaving college he entered the employment of the W. M. Ritter Lumber Company, with whom he remained for twelve years. He left the company to become Assistant Chief on the Cost and Price Department of the Lumber Code Authority, where he worked with Lumber Code Administrator Crawford of the NRA. Shortly afterwards, Mr. Rishell assumed the post of Chief Forester in charge of the Resettlement Project at Salisbury, Md. In addition to this, he was employed (1936) by the National Lumber Manufacturers' Association as Hardwood Products Engineer. Since then Mr. Rishell has worked with the United States Coast Guard and with the Water Transportation Division of both the Army and the Navy, in writing practically all lumber specifications now used for boats. At present he is with the National Lumber Manufacturers' Association.

MANY of the problems of the builders of wood boats for war uses are also problems of the lumber industry. Production of wood boats depends upon a continuous flow of lumber from the sawmill to the shipyard, and that is where the lumber industry becomes a part of the boat building industry.

Prompt delivery of lumber to the shipyard after the order is placed is a prerequisite in maintaining this schedule of production. Prompt ordering of requirements is equally important. Undoubtedly the lumber industry is sometimes at fault for delayed deliveries. Usually, however, the delay is caused by matters beyond its control. For instance, a lumber concern in the South received an order for bending oak and ship timbers during the early part of August. The material was needed not later than August 31. Otherwise, the shipyard would be compelled to close down. On this material, it so happened, it was necessary to present a schedule of prices to the Office of Price Administration. Unfortunately, neither approval nor disapproval of the price schedule presented could be obtained promptly. The shipyard closed down and the production schedule was materially curtailed. This is a matter over which neither the boat builder nor the lumbermen have control.

In general, it should be remembered that to cut and deliver bending oak and ship timbers takes considerable time. It has been estimated that for oak timbers only one tree out of two hundred is suitable for boat building. This means that many acres of forest must be cruised in order to produce the lumber for a single vessel. The lumberman cannot cut his timber in accordance with usual practices. He must cut his ship timbers far in advance of the rails and skid roads. These logs must be dragged to the rail head by any means possible. This is an expensive, tedious, and time-consuming process. Nevertheless, the lumber industry in general has been able to supply all the material that has been needed for the boat and shipbuilding program. Those delays which have occurred, and they have usually been of a minor nature, have been caused by circumstances beyond its control.

It is difficult to give figures on the amount of lumber required for wood boat construction, for even those government agencies who are awarding contracts for boats do not know how much lumber will be needed for their future programs. The best information we have relates to the amount of oak lumber needed by the Navy. These estimates have been variously placed at from thirty to forty million board feet for each quarter.

Up until a short time ago, oak lumber for boats had been purchased principally by the boat and ship building contractor. It is expected that this method of purchase will be continued, but under a central authority fully and adequately informed upon the materials needed so that the orders for white oak lumber can be distributed as widely as possible throughout the industry. In order to bring about this coördination, the Bureau of Ships has been ordered to purchase and regulate the use of white oak lumber for ship building. Where lumber is purchased directly by the government, it will go through the Bureau's hands directly.

However, the Bureau indicates no intention to disrupt the present method of purchasing in which many boat builders have been engaged. It is likely that within a few days a directive will be issued which will require approval on the part of the Navy Department for the purchase of white oak when the amount exceeds one carload. Even though the amount exceeded a carload, this approval will be given as long as it does not disrupt or throw out of gear the coördination in purchase and distribution which has become necessary.

In regard to softwood lumber, which is mostly Douglas fir, southern pine, and cypress, the amounts which will be required are less definitely known than are the amounts of white oak needed. The purchase of softwood will probably be similar to that described for white oak. However, it will not be made through the Bureau of Ships, the actual purchase being made by the Engineer Corps of the Army. Builders of ships for

Oak panels 30 feet long, 3 feet wide, surfaced two sides after gluing to three-fourths of an inch, edge glued with cold setting resin glue. White oak lumber for marine use. Lumber approximately 12 per cent moisture content.
National Lumber Manufacturers' Association

the Navy, Coast Guard, Army, or Maritime Commission will, of course, apply to that agency for lumber. It in turn will request the Engineer Corps to purchase the material. In general, I believe the softwood lumber industry will be able to provide all the material necessary for the production schedule. Like hardwoods, it is necessary to place orders as far in advance of the time needed as possible.

As an overall estimate it is expected that the lumber industry will have produced approximately thirty-two billion board feet of lumber by the end of 1942. There have been various estimates placed upon the amount of lumber which will be consumed for war purposes and for civilian needs. That may be short of the amount which is needed to make everybody happy and comfortable. This does not mean that the boat building program nor any other need for war purposes will be slowed down, but it will undoubtedly mean that civilian consumption will have to be curtailed.

Aside from placing orders for lumber as promptly as possible, there are many other things the boat builders can do to assist in the procurement of an adequate supply of raw materials. Incidentally, these efforts on the builders' part will not only repay them as conservation measures, but should repay them in dollars and cents in the saving of raw material which will accrue. For example, in bending oak frames I happen to know that many boat builders can come much closer to the proper methods of doing this important work.

Some years ago I was called in as adviser to the Coast Guard on the matter of bending oak. It so happened that a 36-foot life boat, which was subjected to severe use, was damaged. It was brought to the yard at Curtis Bay and part of the planking removed which disclosed that all but a few frames forward and a few frames aft were broken. Most of these were broken completely through and spread apart as much as a quarter to a half inch. There were several factors responsible for this damage, and among them was the specification which had been written for the procurement of bending oak. This specification was so written that only very close textured soft white oak could be used. This type of material is exactly opposite from that which should be used for the purpose.

For bending oak, the heavy textured, fast grown material is usually the best. Therefore, the present bending oak specifications as used by the Army, Navy, and the Water Transportation Division of the Army require that it shall have not less than six rings per inch nor more than ten rings per inch. This range in the number of rings permitted of course restricts the amount of material obtainable for this use, but all of the services who have used these specifications have been satisfied that the improvement has been instrumental in saving material and preventing subsequent breakage in the boats. To date all the bending oak necessary to carry on the program has been forthcoming. We hope that the present standard can be maintained, but it might be possible that sufficient bending oak meeting these rigid requirements would not be available, in which event the services will undoubtedly have to modify the requirements as conditions warrant.

You may also ask why white oak is required and red oak is not permitted by most of the specifications. To some of you this requirement may seem unreasonable, for I know that red oak has been used in various sections of the country and in many instances has stood up well. However, it is generally recognized by all authorities of wood that the heartwood of white oak is much more decay resistant than the heartwood of red oak. The argument has been advanced that the boats now being built are to be used only for a limited period; that the war will be over long before decay in the boats can become a serious factor. This may be true. We hope so. Nevertheless, I have yet to find a responsible government official who is willing to venture an opinion as to when the war will end.

If the war in the Pacific develops into guerrilla tactics, it may last over several years. In this case it is probable that all the boats we are building will be needed, not for a short time but for a long time. It seems desirable that the best materials be used in boat construction as long as available. Regardless of how long the war lasts, most of the hulls will be used for government or private purposes, providing that these hulls are sound.

We had an experience in the last war when a large number of wood cargo vessels were built. Many were no doubt improperly designed and improperly built. Nevertheless, because they were of wood, such boats were thought to be a very poor substitute for steel ships. Therefore, it is my opinion that the maritime services of the Government should maintain their requirements for white oak for many purposes as long as the supply is available. These services, however, should keep a careful watch on the supply of material available and when it appears that it is not going to be forthcoming in sufficiently large quantities, red oak or other wood must be substituted. Perhaps some process of preservative treatment can be developed whereby other woods will perform as well as white oak.

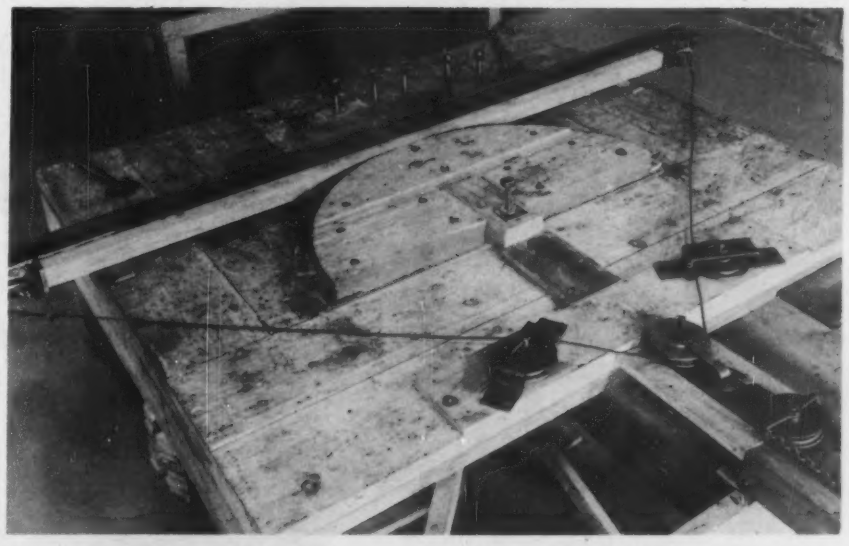
Many boat builders have become concerned because white oak and other boat building species have been used for other purposes. It is true that practically all the species of hardwood with the exception of gum, and many of the softwood species have been used for truck body construction. The Motor Transport Service of the Army estimates that a million to a million and a half feet of lumber per day will be needed for the construction of cargo trucks. Much of this lumber is white oak. Some of it is Douglas fir. However, it does not necessarily follow that the white oak and Douglas fir used for the construction of truck bodies depletes the supply of materials for the boat building program. The lumber used in truck body construction is relatively short and can be of a lower grade than that used for boats. Therefore, if the lumber is properly allocated for truck bodies and for boats, there should be no interference between the programs.

A sore spot in some government specifications has been the requirement of lumber for non-essential or perhaps non-critical purposes of a species and grade which should be used for ship building and other direct war purposes. An instance of this was the specifications for office furniture as worked out by the War Production Board a year or so ago. These specifications required that all desks, filing cabinets, etc., should be of either white oak or walnut. Inasmuch as even at that early date it was anticipated that white oak for ship building would become critical, several staff members of the National Lumber Manufacturers' Association protested vigorously. These specifications eventually came to the attention of the Conservation Division of WPB and the Navy.

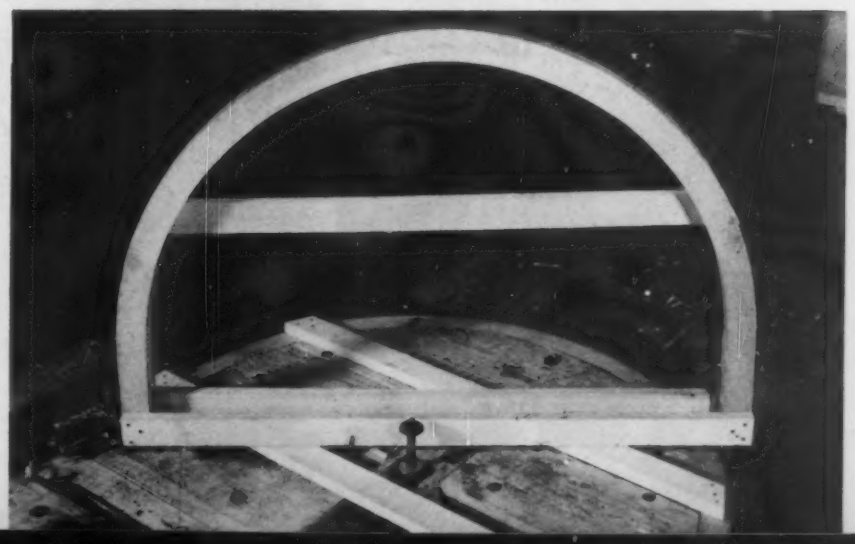
While there is some question as to whether the white oak used for the desks would have been suitable for ship construction, it was assumed by the Navy that some critical white oak was being used and that other species not suitable for ship construction should be used in place of the oak for office furniture. Consequently a directive known as Order M-209 was issued which prohibits the manufacture of (*Continued on page 42*)

Holes and circular grooves are cut into a beam; the metal rings are then put into the grooves

A plank is being fastened to the beam with the circular rings and bolts



One of the frames of a small vessel is shown ready to be shaped



Here, the completed frame is being held together by temporary cross pawls

All pictures courtesy of
National Lumber Manufacturers' Association

LIGHTING THE WAY TO VICTORY

Protective lighting of anchorages of bridge end

Soldering leads on small transformers used by the CAA for its numerous air fields

All pictures courtesy of General Electric

Assembling searchlights for ordnance plants

Spraying open-type floodlights

Inspecting parts of lighting units having the new all-glass reflectors

MESSAGE IN SECRET

CODES AND CIPHERS FORM UNIQUE SYSTEM OF COMMUNICATION

By C. PETER JOHNSON, JR. '45

THROUGHOUT history codes and ciphers have been used to safeguard diplomatic and intelligence messages by making them unintelligible to anyone unfamiliar with the cryptic system used. Although the cipher has been traced far into the past, only recently have the many intricate ciphers available to the spy today come into existence.

In spite of the great variety of secret messages, there are a few fundamental classes of cryptograms. First of all, they can be divided into codes and ciphers. Codes are messages in which words or characters are used to represent words; ciphers are those in which characters are used to replace letters. Although many secret messages have been in code because a code message is suitable for voice transmission and may be disguised sufficiently by plain language to become unrecognizable as a secret communication, the very much more extensive use of the cipher system indicates its greater practicability. One type of code system, the book code, deserves notice because of its extensive use and great security. In this system the successive words of the text are revealed by describing their position in a book, preferably one only in the possession of the sender and recipient. Since a large number of references can be given for a single word, it is almost impossible to solve this type of code unless the book used is discovered.

Cipher systems are themselves subdivided into transpositional and substitutional ciphers. The transpositional cipher is one in which the letters of the message are merely rearranged (Fig. 1). Usually a transpositional message can be reconstructed very easily, for after having determined by a frequency count of the letters that no substitution is used, the cryptanalyst needs only to rearrange the letters until he has discovered the message. Moreover, the cyclic repetition of the order of transposition commonly found in transpositional ciphers permits the analyst to discover readily the key to the message, and, therefore, the message itself. By multiple transposition and by the use of nulls, of letters having no significance, the message can be made somewhat more secure. The principal use of transposition is, however, to increase the security of a substitutional message. Indeed, transposing the characters of a cipher after changing them into other letters by a good substitution system will offer an insurmountable obstacle to all but the most intelligent cryptanalyst.

The substitution cipher is, by all odds, the type of secret message which offers the greatest security. Its only disadvantage is that the use of jumbled characters reveals to a cipher expert that he is dealing with a cipher. The simplest type of substitution is the displacement cipher, in which each letter is substituted by a letter a definite number of places forward or backward in the alphabet. Since this cipher is readily deciphered by even the most inexperienced analyst, it is almost never used. A more difficult type of cipher is the monoalphabetic substitution cipher, in which each letter of the alphabet is substituted throughout the message by another definite letter. However, even this type of message (Fig. 2) is rarely used for very important documents, unless it is transposed after it is formed, for otherwise it is very easily solved. A more complicated type of cipher is one in which pairs or triplets of letters are substituted for as a group. Figure 3 illustrates one of this type.

The king of ciphers is the polyalphabetic substitutional system. In this system the letters of a message are replaced by the corresponding letter in any one of many straight or mixed alphabets. Probably the simplest polyalphabetic system is the Vignere one, which has for many years answered the secret agents' desire. The basis of this system is twenty-six alphabets in usual order but beginning with the successive letters of the ordinary alphabet (Fig. 4). These new alphabets are arranged in a square, each alphabet below the preceding one. The letter to be substituted for a given letter, for instance *c*, is determined by following the column of letters directly under the *c* of the first alphabet until the random alphabet chosen for the substitution is reached. The letter found there is the letter to be substituted for *c*. Since a random alphabet was chosen for the substitution, a random letter was used for *c*. Hence it follows that any secret message enciphered by this system can have any translation whatever, and the Vignere cipher is incapable of solution. Thus in spite of the widespread belief that any cipher can be solved, the Vignere cipher is an example of one that is absolutely insolvable. In the Vignere system the cryptanalyst has, indeed, met his Waterloo.

In practice, however, a modification of the Vignere system is used that is capable of solution. The twenty-six alphabets are referred to according to their initial letters, and the letters of a keyword or key phrase determine the order in which the alphabets are to be used. Thus if "studio" were the keyword, alphabets *s*, *t*, *u*, *d*, *i*, and *o* would be used in this order again and again. Thus the cryptanalyst needs only to discover the keyword in order to solve the message. The security of a message of this type is greatly increased by using

Peter Johnson, Jr. is a sophomore student in chemistry at M. I. T. He was born in 1924 in Montclair, N. J., but has lived most of his life in Washington, D. C. He graduated from St. Albans school in Washington before coming to Tech. Johnson is a member of Phi Delta Theta fraternity. Through his work on the T.E.N. *he recently became an associate editor. He is strongly interested in chemistry, and is a member of both the M. I. T. Chemical Society and the American Chemical Society. Last year he received the Alpha Chi Sigma freshman chemistry award. This is his second article in* THE TECH ENGINEERING NEWS.

ILLUSTRATIONS.

Fig. 1. A transpositional cipher. A rectangle is divided into horizontal and vertical rows of squares. The successive plain-text letters are put into successive squares of the first horizontal row until it is filled. The other rows are then filled in turn. Finally, the unfilled squares are occupied by nulls, letters having no significance. The vertical columns are then used in a definite order to make the final cipher.

```
Order of columns: 2 1 5 4 3  Plain text:
                  M O V E S    move supplies to rear.
                  U P P L I  Translation:
                  E S T O R    opsamueesirxelonvptr.
                  E A R N X

The cipher can be transposed again:
Order of columns: 2 1 5 4 3  Translation:
                  O P S A M    pexvournmiorasltseep.
                  U E E S I
                  R X E L O
                  N V P T R
```

Fig. 2. Monoalphabetic substitution. In this system each letter of the alphabet is translated throughout the message by another letter.

```
Plain-text letters:
  A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

Translation:
  F M E O I B H L Q J P A R G T S K U N V D W Y C Z X
Message: Move supplies to rear.
Translation: rtwi ndssaqin vt uifu.
```

Fig. 3. An example of diagrammatic substitution of groups of letters. The letters of the alphabet, with the exception of z, are arranged in a square in five rows and five columns. The letters of the message are located two at a time in the square. The two letters that are found at the intersection of the rows and columns containing the two original letters are the translation of the original letters. The translation letter found horizontally opposite the first original letter is used first in the final translation. Thus MO (see below) is translated by QN, and OM would be indicated by NQ.

```
Message:      MO VE SU PP LI ES TO RE AR   H R K D T
Translation:  QN JF CV PP AS FX DL RE GK   N G A O L
                                           B X I C S
                                           X J W U V
                                           M E P Q F
```

Fig. 4. The Vignere system. A letter to be enciphered is located in the top alphabet. Then the column of letters below it is followed until an arbitrary horizontal alphabet is reached. The letter found there is the translation of the original letter. Thus the translation of C in the 16th or P alphabet is R.

In the message translated below, "Move supplies to rear," a keyword, "studio," is used to indicate the order of use of the alphabets. Thus the horizontal alphabets beginning with s, t, u, d, i, and o are used in turn.

```
 1 A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
 2 B C D E F G H I J K L M N O P Q R S T U V W X Y Z A
 3 C D E F G H I J K L M N O P Q R S T U V W X Y Z A B
 4 D E F G H I J K L M N O P Q R S T U V W X Y Z A B C
 5 E F G H I J K L M N O P Q R S T U V W X Y Z A B C D
 6 F G H I J K L M N O P Q R S T U V W X Y Z A B C D E
 7 G H I J K L M N O P Q R S T U V W X Y Z A B C D E F
 8 H I J K L M N O P Q R S T U V W X Y Z A B C D E F G
 9 I J K L M N O P Q R S T U V W X Y Z A B C D E F G H
10 J K L M N O P Q R S T U V W X Y Z A B C D E F G H I
11 K L M N O P Q R S T U V W X Y Z A B C D E F G H I J
12 L M N O P Q R S T U V W X Y Z A B C D E F G H I J K
13 M N O P Q R S T U V W X Y Z A B C D E F G H I J K L
14 N O P Q R S T U V W X Y Z A B C D E F G H I J K L M
15 O P Q R S T U V W X Y Z A B C D E F G H I J K L M N
16 P Q R S T U V W X Y Z A B C D E F G H I J K L M N O
17 Q R S T U V W X Y Z A B C D E F G H I J K L M N O P
18 R S T U V W X Y Z A B C D E F G H I J K L M N O P Q
19 S T U V W X Y Z A B C D E F G H I J K L M N O P Q R
20 T U V W X Y Z A B C D E F G H I J K L M N O P Q R S
21 U V W X Y Z A B C D E F G H I J K L M N O P Q R S T
22 V W X Y Z A B C D E F G H I J K L M N O P Q R S T U
23 W X Y Z A B C D E F G H I J K L M N O P Q R S T U V
24 X Y Z A B C D E F G H I J K L M N O P Q R S T U V W
25 Y Z A B C D E F G H I J K L M N O P Q R S T U V W X
26 Z A B C D E F G H I J K L M N O P Q R S T U V W X Y

      Key letters: STUD IOSTUDIO ST UDIO
          Message: MOVE SUPPLIES TO REAR
      Translation: EHPH AIHIFLMG LH LHIF
```

Fig. 5. An example of a plain-text message containing a cipher.

Dear Nancy,
I have found now that John is still in New York.--Henry.

The first letters of the words give the cipher: DNIHFNTJISINYH, which was formed by monoalphabetic substitution according to Fig. 1. The reconstructed message is USEGASOJEPESWG, of which only "use gas" is significant.

mixed alphabets in place of the regular-order Vignere alphabets, by using long key phrases or a random group of letters to represent the order of use of the alphabets, and by transposing the message after substitution. Thus an almost insoluble cipher can be made with moderate ease.

For secret agents continually using a code or cipher it is a prime requisite that the message be completely hidden, for practically any cipher can be solved if it is discovered. History is full of means that have been used to disguise secret communications. Small dents on the tops of coffee cans, ink dots on a thread woven into a garment, and apparently harmless designs have been used to hide a message. One of the best ways to hide a message is to conceal it in an ordinary one. For instance, the first letters of a plain-text note may be used to form a cipher (Fig. 5). So many times, indeed, has secret communication been successfully disguised and remained undetected until other evidence brought it to light that the secret agent's first thought before sending a cipher should be the proper concealment of his message.

Since an infinite number of complex ciphers and clever ruses can be used by a secret agent to conceal his correspondence, it is a wonder that a well-constructed secret message has ever been solved. Nevertheless, it is well known that practically any cipher can be reconstructed once it has been detected as a cipher. Simple transpositional and substitutional ciphers are detected by means of a frequency count of the letters. The simpler polyalphabetic ciphers present a much greater difficulty, for in general they necessitate finding an arbitrary keyword.

In practice the deciphering bureau is often aided by auxiliary information that it secures. The use of military intelligence to discover the nature of messages has played a large part in wartime solution of ciphers. Furthermore, for practical use a cipher must be simple enough to be readily constructed by the sender and readily translated by the receiver. Thus reconnaissance and intelligence messages used in wartime usually utilize a rather simple cipher system. When private footsoldiers are used for reconnaissance, an especially simple cipher is a primary requisite. Indeed, the solution of military messages can usually be done so rapidly that an organization sending a secret message relies on the cryptic nature of the communication only to delay the enemy a short time and to prevent his immediate action in response to the message.

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FRANKLY SPEAKING ...

HOW MUCH CAN WE EXPECT FROM SCIENCE?

To hash over the marvelous advances and results of science that have appeared within the past fifty years would be an old story. Even the majority of strictly "non-technical" men, and quite a few of the women, too, living in America today have become reasonably familiar with such terms as the internal combustion engine, electronics, nuclear physics, and aeronautics.

Only within a comparatively recent time has the realm of pure science given to us some of the most radical, yet beautiful, concepts of the basic quantities of which everything material is composed, matter and energy. We do not have to think back very far in order to remember about the transmutation of elements of the more recent studies of the cosmic ray. With the introduction of microchemistry, a whole new field was opened up to the chemist, while in close conjunction with him have worked the men of medicine, reducing human suffering and increasing the span of life.

In the field of applied science, the engineers have designed and made possible the production of machines that give us everyday services which the most rich and powerful ruler in ancient times would not have had the imagination to dream of. Notice how provoked you become if your electric toaster suddenly refuses to heat or your automatic furnace stoker gets a load of the wrong kind of coal, and how inconvenienced you feel when the last ticket on your gas ration book has been used. Yes, it is an old story, this one of the advances of science, old because we have come to take for granted that science will solve most of our problems for us.

And yet with all of these accomplishments, something seems to be missing, or maybe we should say so many other problems are still present. In pre-war days there were problems such as unemployed millions, automobile accidents so unnecessarily taking the lives of thousands, and going back a little further, the wretched municipal government of our cities. Some of these problems still exist today, but they are far overshadowed by the one that we dread most, being in a war itself.

Many people are inclined to believe that since many of our problems are supposedly caused by scientific advances, that if we would eliminate such research, all of these problems would disappear.

Still others say that maybe these problems are due to science or maybe they are not. Nevertheless, they argue that if science can provide us with so many comforts and conveniences, why can it not solve these problems? It is here that we run into the question: "How much can we expect from science?"

The question is really one of how far does the scientist's field extend. Can we rightfully blame the developers of the automobile if drunken driving and carelessness have caused most of the accidents of recent times, or if technology has completely taken over the methods of warfare? To those who would say that such misfortunes are the result of science, it may be well to say that it is largely the utilizers of scientific advances who are responsible for such conditions. Even our most applied engineers are not trained to set up and enforce a system of moral behavior, or to solve the economic and diplomatic problems which are ever present. Instead, the scientist is a student of the laws and facts of nature. He can give us many new and wonderful things to use, but it is the responsibility of the appliers, be they ordinary citizens or influential leaders, to see that the tremendous power of such advances is used correctly.

WHICH would you vote "most likely to succeed?"

"The Aircraft Warning System gives a single plane on ground alert the equivalent striking power of 16 planes on air patrol." This startling statement comes from England.

Our country's Aircraft Warning Service — quite similar to England's—keeps a constant check on the flight of all aircraft. Should the need arise, it is prepared to send fighter planes aloft, to mobilize and direct ground defense forces, to warn endangered areas. Every step in its operation requires the fast, accurate communication of the telephone.

This is just one of the many wartime jobs that are keeping telephone lines busier than ever before. To help us keep lines clear for vital military and industrial calls, please avoid using Long Distance to war activity centers unless the call is urgent. And please keep all your telephone calls as brief as you can. Thank you.

WAR CALLS COME FIRST!

BELL SYSTEM — AMERICAN TELEPHONE & TELEGRAPH CO. AND ASSOCIATED COMPANIES

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Twenty-inch bracket for protective lighting or other application in congested area

General Electric

Portable battery-operated floodlight

General Electric

Floodlighting projector, Type L-66, 200-watt capacity, having widespread beam. Oblique right-side view (from front)

BRIEFING THE NEWS...

NEW LIGHTING DEVICES FOR PROTECTION AND DIMOUT

To fit in with present dimout lighting, four new appliances have been developed:

A new 20-inch right-angle bracket is particularly adapted to plants located in congested areas. The bracket, equipped with a 500-watt lamp, will provide a well-lighted area between the building and the street. The brackets are mounted 22 to 28 feet high and about 150 feet apart.

For use during blackouts or other emergencies, or in such places as powder magazines which cannot have installed lighting, a portable battery-operated floodlight has been developed. The battery, a five-cell storage battery, is stored in a small steel box (19 by 9⅞ by 20¾ inches) on which is mounted by means of a universal bracket a special dust-proof, vapor-proof lamp housing. Combining the pre-focus positioning of the 50-candle-power, concentrated-filament type bulb and diffusive lens with a high-efficiency glass reflector gives a powerful medium-angle floodlighting distribution. The normal burning time is about 10 hours.

By means of a new switch, traffic signals can be satisfactorily controlled during a blackout. The switch consists of a transformer and a single-pole switch with two positions. With the switch at "normal" the signal lamp burns at full brilliancy; at "blackout" the voltage is reduced and the lamp filament just glows. Each signal lamp must be provided with a visor to screen the upward light.

To provide ample light for airports, docks, and other areas needing powerful outdoor light, a new floodlight featuring a combination of the socket housing and reflector, die-formed in one piece, has been developed.

Blackout control device suggested to dim traffic signals during air raid and afterwards to switch them back to normal for regular operation

PLYWOOD HAS MANY WAR USES

More than a billion board feet of plywood per year are now replacing steel in airplanes, barracks, boats, houses and hangars. Because of its light weight and great strength it has been widely used in aircraft construction. One of the most successful British bombers has regularly been made of birch plywood. Many forms of boats are now being made of plywood. This has been made possible largely through the development of water-resistant and heat-resistant glues. Modern plywood can even be immersed for hours in water, or subjected to exceedingly high temperatures without changing its size, strength, or shape.

Today most plywood is made of three or five cross-bands of veneers — thin sheets of wood from 1/100 to ½ inch thick, placed together in crosswise directions. Almost any kind of wood can be used; because of the large size of logs available and the straightness of the stems, great quantities of Douglas fir are now being used.

Large unbroken sheets of veneer are produced by placing a log in a huge lathe and turning it against a sharp knife. In this way, continuous sheets of veneers are peeled off the log until the log, originally 30 to 50 inches in diameter, is reduced to about eight or 10 inches in diameter.

The consumption of logs for plywood veneers has increased five-fold in less than 40 years. In 1905 only 181 million board feet were used annually, as against the present estimated consumption of a billion board feet.

Laminated wood, not to be confused with plywood, is another form of compressed veneers wherein the various layers or piles are laid lengthwise instead of crosswise. This laminated wood is used in the manufacture of gun stocks and airplane propellers.

BLACK LIGHT FOR BLACKOUTS

The use of black light to faintly illuminate objects coated with fluorescent materials is now being used extensively in blackout preparations for industrial plants. The outline of corridors, vital switches, machines, pitfalls, etc., are given treatment with a fluorescent material not evident in normal light, but visible when ultra-violet light is trained upon it during a total blackout. The absence of glare or appreciable reflection affords no aid to possible enemy agents, and no light is visible from the air. This procedure has been adopted outside as well as indoors at power plants, production centers, and even on ships.

The combination of ultra-violet and fluorescent materials has long had direct military applications. In aircraft, dials, gauges, and pointers must be visible to the pilot and his crew, and yet light must be minimized so that the presence of the plane is not disclosed by illumination and the men are not handicapped by facing enough light to cause contraction of the pupils of their eyes.

AIRPLANE ENGINE MAKERS CONVERT WASTE TO PRIME POWER

When airplanes leave the assembly line, they must be ready for full service, and no break-in of the engine is possible. Accordingly all engines are given a break-in run by their manufacturer before installation in their ships.

If allowed to run free, the motors would blow up, and so standard practice has (*Continued on page 44*)

Scratchboard drawing in Higgins Ink by W. Parke Johnson. Courtesy of American Telephone & Telegraph Co.

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ALUMNI MOVE ON

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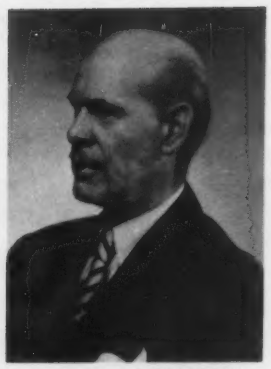


A. H. B. JEFFORDS

A. H. B. Jeffords, management engineer with the Trundle Engineering Company for the past several years, has been made a vice-president, it has been announced by George T. Trundle, president of the company. He will take over various administrative duties in the Cleveland office, specializing on war production rules, regulations and requirements.

A graduate in Mechanical Engineering from Massachusetts Institute of Technology, Mr. Jeffords has had a wide and varied experience in industry. He was the Sales and Traffic Manager of the Consolidated Telephone Company of Pennsylvania when the opportunity came in 1915 — in the midst of World War I — to become an executive of the Carney's Point Plant of E. I. duPont de Nemours & Company, the largest explosives plant in the country at the time.

Late in 1917, just ahead of the United States entry into the war, Mr. Jeffords became general manager of the Standard Aircraft Corporation, Elizabeth, N. J. This was then the largest aircraft plant in the world and engaged in the production of several types of military planes, including the Handley-Paige and de Haviland bombers and the manufacture of the J-1 training planes. With the end of the war many of the planes built by this company were revamped under Mr. Jeffords' direction to become the original ships with which the Air Mail was established.

In 1920, Mr. Jeffords joined the Sherman Corporation, Engineers, as vice-president in charge of operations. Four years later he came to the Trundle Engineering Company and has made Cleveland his home.

Loren Dickerson was included in such distinguished company as Bernard M. Baruch, Carter Glass, William Lyon Phelps, and William Allen White as one of the 28 new members recently (November 10) elected to membership in the 200 Associates of Phi Beta Kappa, the national scholastic honorary society. The Associates were formed in 1940 to lead Phi Beta Kappa, which now has over 90,000 members, into a more active participation in present world affairs. The group, which is limited to 200, includes Lincoln Filene, Charles Evans Hughes, Hans V. Kaltenborn, Roscoe Pound, Nelson A. Rockefeller, and Theodore Roosevelt.

Mr. Dickerson, who is 24, is the youngest member of the Associates and the only industrial chemist in the group. He received a Bachelor of Science degree from Emory University, Atlanta, Georgia, and will soon receive a Doctor of Science degree from Massachusetts Institute of Technology, where he studied a phase of fluid flow now used in research by the armed services. Mr. Dickerson is now engaged in chemical engineering research on war production facilities for Arthur D. Little, Inc., consultants on industrial research.

WOOD FOR SMALL BOATS

(*Continued from page 32*)

veneers from white oak logs. This order will of course put an immediate stop to the production of white oak office furniture and the objectionable specifications will have to be changed.

Another instance in which critical materials have been used when other lumber not so much in demand would have served as well, can be found in the recent specifications by the Maritime Commission for landing barges. These specifications required that only select structural (2000#) long-leaf southern yellow pine could be used for framing, planking, and decking. This grade of lumber is the highest type of any southern pine structural grade. It is produced in very limited quantities and should never be specified unless the use to which it is to be put requires the very strongest lumber — southern pine.

Without going into technical details, our opinion is that the frames for the barges could have been made of 1200# timber and provided as much strength as the 2000# grade. This is because most of the stresses were in shear rather than in bending. Furthermore, the planking of the barges was only one inch thick. Structural lumber is not manufactured in thicknesses less than two inches, but the specifications were so written that 2000# lumber of two inches in thickness should be resawed to one inch, the supposition being that the one-inch boards would then be up to a 2000# grade. This of course is not the case. Structural lumber is graded on knots, the position of knots, etc. It is intended that it shall be used in its full length and width. Any remanufacturing, such as resawing, is apt to change the grade characteristics, that is, the strength of the piece. There were several of the lower grades which would have provided planking and decking with every essential requirement for strength, etc. The barges were built in accordance with the specifications. It is estimated that it took six million feet of select structural long-leaf yellow pine to do the job. This material should have been saved for light, high speed, and highly stressed boat hulls.

The boat building industry can assist in the conservation of boat lumber. Every foot of waste which is prevented means that much more toward the useful program. For example, steam bending of white oak frames is an important place to look for and prevent waste. Many boat shops have not improved their methods for bending in the last fifty years. I have visited some yards where the breakage in white oak frames during the process of bending has been 50 and sometimes 60 per cent. Considerable research has been done to assist in preventing this breakage by the revision of Coast Guard and Navy specifications, in the use of which it is assumed the builders will obtain material best suited for the purpose.

However, the proper methods of bending are perhaps as important or more so than the type of material chosen. Extensive studies have been made on bending by the Forest Products Laboratory. They have developed bending clamps and have suggested processes whereby breakage can be (*Continued on page 44*)

The rat that went to college...

CHARLEY, the large and healthy white rat shown above, not only goes to college but he lives in a glass house!

For Charley is one of the thousands of white rats used for scientific research in American college laboratories. His glass house is a Pyrex animal jar, for a couple of good reasons: One, because of its exceptional mechanical strength. Two, because Pyrex glass can be sterilized in live steam without breaking or becoming cloudy, which makes it a favorite with laboratory men.

Pyrex laboratory ware, developed during the last war to replace imported glass, is just one of Corning's many research contributions to better living. Others are everywhere. The glass tubes in your radio. Beacons that guide American planes. Glass pumps and piping in busy chemical and food plants. Signal lights and insulators on our warships.

Corning knows glass. Knows how to make it resistant to chemicals and heat, strong and hard to withstand impact and abrasion, accurate to tolerances ranging as low as 0.00002 of an inch.

This knowledge is being put to good use today. A special sanitary glass piping, for example, has just been developed to ease the dairy industry's shortage of metal. The communications industry, faced with a sudden wartime demand for insulators in intricate shapes and with special electrical characteristics, is using glass insulators quickly developed by Corning.

Design engineers who are licking this war's problems are finding ever new uses for glass. For tomorrow's engineers also, glass is the material with unlimited possibilities. Industrial Division, Corning Glass Works, Corning, New York.

CORNING
means
Research in Glass

BRIEFING THE NEWS . . .

(*Continued from page 41*)

been to load them with a propeller, usually in a test cell to decrease noise and even air disturbance.

By replacing these test propellers with ordinary generators such as are used with Diesel sets, the desired drag is imposed on the engines. This method also eliminates the need for test cells and provides a major source of power for the plants.

One leading manufacturer of engines has learned that each new engine will turn up about 2,000 kilowatt-hours in its test run. Considering an average monthly output of about two thousand engines, this would mean a saving in electric power of $24,000 a month. Another important advantage is that the generators serve as starting motors for the engines, and through observation of power output, provide a check on the engines' performance.

WIND TUNNELS VITAL IN AIRPLANE TESTING

The wind tunnel is proving a quicker and better way of determining the aerodynamic characteristics of new aircraft than the test pilot.

In the United States, wind tunnels are maintained by the Army Air Force, the Navy, the National Advisory Committee for Aeronautics (NACA), some large aircraft manufacturers, and a few universities and technical schools.

These tunnels consist of closed tubes through which air is blown at high velocity by means of a propeller, and which are so constructed as to direct a smooth, non-turbulent current of air against whatever device may be placed in them. The part to be examined is placed in an open space in front of a funnel-like construction in the tube, where it is subjected to the full blast of wind. Behind it, the tunnel picks up the air again and re-circulates it. Thus a part of a plane or model aircraft may be held firmly in place by one or more supports, and the desired *lift* and *drag* forces acting upon it recorded on scales. In addition, a wake survey apparatus may be installed directly behind the model under test, so that the effect of the surface upon the air current may be found.

Before a new type airplane goes into production it is first tested in a wind tunnel. Although tunnels have been built for full-sized surfaces, most wind tunnels are only large enough, for obvious practical reasons, to contain model-sized planes. The model will not behave precisely as its prototype under the same conditions, however, and the problem is more than merely blowing a current of air at a model to tell how a big plane will fly. The relative dimensions of air molecules to a large plane and to a small plane are quite different. To get around this difficulty the air current can be kept at a velocity suitable for a full scale plane and the results corrected with the model; on the other hand, the air flow may be altered, speeded up usually, and the results will correspond to the true behavior of a large scale airplane. A new NACA installation has a top wind speed of better than 500 m.p.h.; the new supersonic tunnels have velocities upwards of 1000 m.p.h. — faster than sound. Lately, compression of the whole air system in a tunnel has been practiced to obtain true to scale indications, when using small models.

The study of drag forces in wind tunnels has proved that even the slightest surface irregularity can cause considerable skin friction. For example, a coat of spray paint on the wing of a transport moving 225 m.p.h. created a loss of 91 horsepower, compared with a smoothly polished surface. Fine grain sand 5/10,000 inch thick also had a noticeable drag effect on a wing surface upon which it was put. In line with wind tunnel findings, all unnecessary projections have been eliminated from modern planes, or have been streamlined to reduce, as much as possible, the air resistance caused. Engines, for example, are always enclosed in cowlings; the removal of this large source of resistance has resulted in many more miles per hour of air speed in modern airplanes.

Great progress has been made in recent years in smoothing out the air flow in wind tunnels. Tunnels for studying propellers have been devised, and special vertical tunnels have permitted studies of the spinning characteristics of models, as research workers on the ground solve the problems of flight without going aloft.

WOOD FOR SMALL BOATS

(*Continued from page 42*)

reduced to a minimum. If the proper material is chosen and the proper bending methods instituted in the plant, breakage of frames should be reduced to not more than 10 per cent and in many instances can be reduced to five per cent.

There is a great deal of controversy as to the proper method for steaming or moistening lumber preparatory to bending. However, various experiments indicate that heat is more important to the process than moisture. As an example of this some tests on bending frames for Coast Guard boats were made. The white oak frames were placed in a steam box in which they were steamed and soaked for two hours. The initial moisture content upon entering the steam box was 13 per cent. After steaming and soaking for two hours, the average moisture content was increased only four per cent. Most of this increase was of course on or near the surface of the lumber. Though no positive conclusions can be drawn from this test, it would appear likely that thoroughly heating the wood is probably more important than the increase in moisture content.

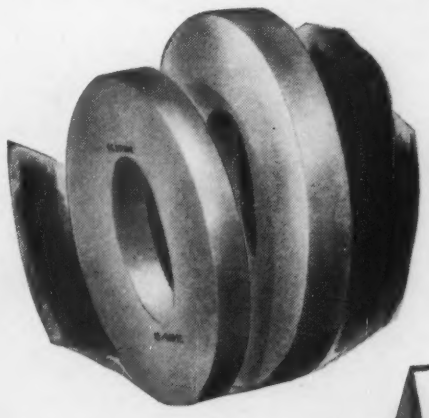
The main point to remember about bending is that wood will stretch lengthwise in tension less than one per cent of its length, but that it will compress without material damage as much as 20 per cent in length. In bending, the convex side of the piece tends to elongate and the concave side of the piece compresses or becomes shorter. The problem, therefore, is to prevent the wood from stretching on the convex side and to force it to compress or shorten on the concave side of the piece. Within reasonable limits, when this is done, white oak can be bent without breakage. The equipment used for the purpose is known as bending clamps, which are simply strips of metal with end pieces fitted on in such a way that the stick to be bent is snugly contained between the end blocks. In bending the clamp and the stick, the end blocks remain stationary and prevent the stick from elongating on the tension side and force it to compress on the compression side.

There are good reasons to believe that within a short time new developments in lamination will become very important. We anticipate that if lamination is used on a large scale, it will be the most important single factor in maintaining an unfailing supply of material for boat and ship construction. Laminating boat parts by gluing has been made possible by the development of new glues which have been on the market for only the past three or four years. About two and one-half years ago (*Continued on page 46*)

Now they fly ten times as long without overhauling!

The flimsy crates of World War 1 needed overhauling after as little as 24 flying hours. But today's planes fly hundreds of hours at much higher speeds before a major overhaul. The reason? New materials, new designs and new methods of finishing metal surfaces. Finishes so nearly perfect that bearings, cylinders, pistons and cams are made practically wear-proof! It's a process in which Carborundum has played an important part...by supplying the finishing wheels and stones required.

Formerly ultra-finishing was a long tedious task. But thanks to the new process, finishes accurate to a few millionths of an inch can now be produced on ground surfaces on a production basis. Application of these finishes to wartime engine production has improved the fighting efficiency not only of planes, but of tanks and other motorized equipment. Fewer men are needed for maintenance and repair.



Ultra-finishing—is only one of many ways in which Carborundum may be able to help save precious time. When you get out in the field and encounter a production problem that abrasives might solve, write The Carborundum Company, Niagara Falls, New York.

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WOOD FOR SMALL BOATS

(*Continued from page 44*)

the co-operation of the Navy in a program of research on lamination was secured. Experiments have been conducted by the Navy Department with the advice and assistance of the Forest Products Laboratory. Within the past twelve months the Navy Yard at Norfolk has constructed two fifty-foot boats in which the keels and frames have been of laminated white oak. These are now in the water and will be closely observed from time to time. Apparently the experiments have been so successful that the Navy has changed its specifications to permit the substitutions of laminated for solid wood in many of its boats.

About six months ago we were successful in interesting the Coast Guard in developments along this line. A glued laminated keel was built for them by the Mengel Company of Louisville, Kentucky. This keel was built with the stem and horn timber attached. A boat was built around the keel and is now in the water. After six weeks of use the boat was pulled out of the water, the paint scraped off the keel and an examination made. No damage whatever or any indication of delamination can be detected. This keel was built of Douglas fir in accordance with specifications for that type of boat. Within the next few weeks we hope to have another boat under construction in which the keel will be of white oak.

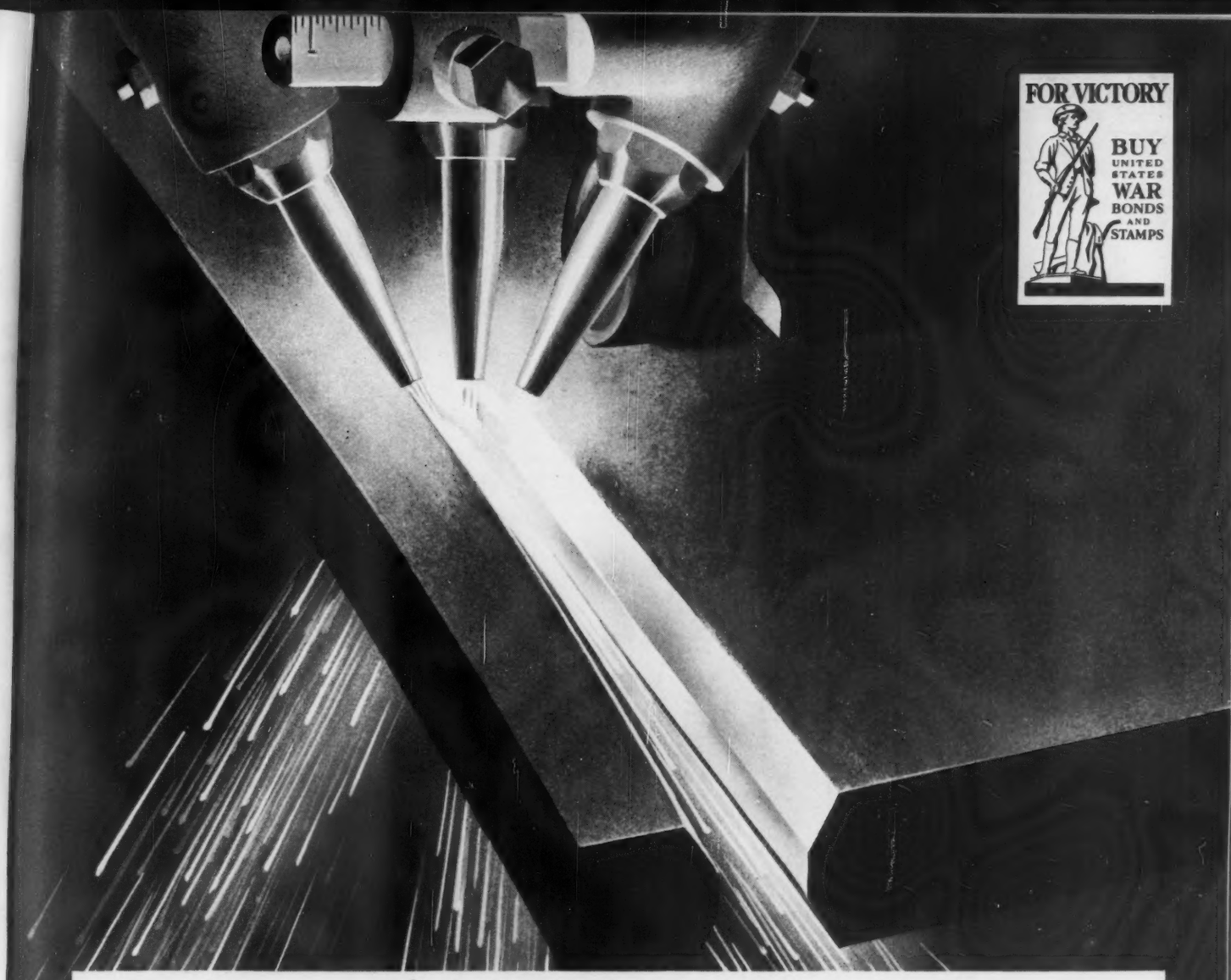
We believe that the success of the various experiments conducted in glued laminated keels and frames will encourage the Government and the lumber industry to construct laminating plants where boat keels, stems, frames, and other parts can be laminated in any size required. In fact, preparations are well under way for the establishment of such plants. I predict that it will not be very far in the future until keels from 120 to 180 feet laminated into one piece can be ordered, either with the stem permanently attached or separate. It will probably be possible to obtain sets of frames completely laminated and ready for use.

In the beginning of this article, I mentioned the fact that only one white oak tree out of every 200 was suitable for use in boat construction. If laminating develops as we hope and expect it to, the other 199 white oak trees can be used to a large extent for boat building. Furthermore, we will be able to take long lumber of low grade, cut it up to secure clear material, glue the short pieces together and provide structural parts which are stronger than the solid materials used in the past. Other benefits will accrue from this laminated process. Not only will it be possible to procure long timbers but it will also be possible to procure timbers which have been dried to the proper moisture content. At the moment there are no large, solid timbers available in low moisture content. Large timbers of the sizes needed for ship construction may take two to five years to dry. This of course is impossible under war conditions. Therefore, boat builders have had to use green timber. With laminating, however, we propose to cut all the lumber into inch thicknesses, dry it in dry kilns to the proper moisture content, laminate it into timbers of the proper size and ship it in perfect condition in all respects.

There are two types of glues of the waterproof variety which have suitable properties for the construction of laminated boat members. The first of these, and at the present time the most important, is the cold setting urea type. This glue is thoroughly waterproof and when properly used will provide laminated members that will not separate under conditions encountered in normal boat use. The limitation which prevents the use of this glue for some purposes does not hold for boats, *i.e.*, it becomes plastic at temperatures in excess of 180 degrees. The urea glues have become very popular and are quite widely known. They are used by many boat concerns. Also they have come into wide use for the lamination of truck body members. Certain elementary precautions must be taken in the use of this material. If the limitations in using this glue are not well understood, trouble will be experienced when using the glued-up product. It is, therefore, not advisable, at least at the present time, for the inexperienced to attempt to use the glues for laminating heavy members. This should be left to firms who have the equipment and personnel for handling it. A few of the limitations are as follows: (*Continued on page 48*)

Thirty-six foot landing boats, United States Navy. Manufactured by Owens Boat Company, Baltimore, Md.

National Lumber Manufacturers' Association



FLAMES THAT CUT TIME!

TODAY, ships are needed as never before. And today, ships are being built as never before . . . and built faster, stronger, and with less steel . . . thanks to welding!

But before welding can take place, steel plates have to have their edges beveled and squared-up so that, when butted together, they look like this: or like this:

In the past, preparing plates in this manner was done by heavy machine tools. Cutting was slow and costly. Each plate had to be handled many times. Plate cutting on this basis could hardly keep pace with welding today.

Now, oxy-acetylene flames . . . *cutting in different planes simultaneously* . . . prepare the edges of steel plates of any commercial thickness *at one pass* . . . in a fraction of the time required by mechanical methods!

This Linde flame-planing method is as simple as ABC. It is economical . . . and easy to use. It cuts plates so smoothly and accurately that *no machining is necessary!* And it uses materials which can be produced in abundance.

On-the-job power requirements for flame-shaping are negligible . . . for the reaction of the cutting oxygen jet with the hot steel does all the work . . . and only fractional horsepower is required to move the cutting nozzles along the line of cut.

In conjunction with "Unionmelt" Welding . . . an amazing electrical welding process that unites plates of any commercial thickness faster than any similarly applicable method . . . like this . . . the Linde method of plate-edge preparation is working miracles in speeding up shipbuilding.

These two methods are also helping to break production records in other fields. Great pressure vessels . . . locomotive boilers . . . huge pipes . . . heavy chemical tanks . . . combat tanks . . . artillery mounts . . . and other vital equipment are being turned out faster because of them.

Linde research, intensified today, is constantly solving new problems in flame-cutting, flame-fabricating, and flame-conditioning of metals for war production.

The important developments in flame-cutting—and other processes and methods used in the production, fabrication and treating of metals—which have been made by The Linde Air Products Company were facilitated by collaboration with Union Carbide and Carbon Research Laboratories, Inc., and by the metallurgical experience of Electro Metallurgical Company and Haynes Stellite Company—all Units of Union Carbide and Carbon Corporation.

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STEEL TAPE Here's a sturdy, easy-to-read quality tape you will appreciate. Surface won't crack, chip, rust or peel. Genuine leather cover on steel case. Smooth winding mechanism. See it at your dealer and write for catalog.

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TAPES · RULES · PRECISION TOOLS

WOOD FOR SMALL BOATS

(*Continued from page 46*)

The pieces to be glued must be put under pressure within fifteen minutes after the glue has been spread. The surface of the pieces should be as near perfect as possible. The ordinary planers are not suitable for this type of surfacing. The pressure must be continuously maintained over a period of eight to ten hours, and the laminated parts should not be put in the water or subjected to heavy strains in a shorter time than eight days after gluing. These are only a few of the rudimentary principles. There are many other factors which must be taken into consideration.

The second type of glue is the hot press or thermal setting glue. This can only be used when it is possible to apply relatively high temperatures to the glue line. These glues are widely used in the construction of plywood panels. Hot presses are the medium for transmitting the heat. This same process cannot be used for laminating heavy timbers. It is too difficult, if not impossible, to transmit heat through the wood to the glue line in such large pieces. There is a process being developed, however, known as the thermax system. This is an electric process by means of which heat can be transmitted to the glue line in a very short time. With this system it is not necessary to heat the wood, but only the glue line and the adjacent surfaces thereto need be brought to the proper temperature. This process requires a large amount of expensive equipment and can probably be used only where exceptionally large quantities of laminated materials are needed. So far as we can see at the present time, this equipment will be too expensive and too complicated for installation in boat yards. It will be confined to large manufacturers of lumber or lumber products.

FROM PLEASURE CRAFTS TO PATROL BOATS. ***Patrol boats for the United States Coast Guard are now coming off the ways of an East Coast shipyard which formerly built small pleasure boats. Fabricated of wood, each boat costs approximately $100,000. Some phases of construction of these boats are pictured in this set of four photos. Here workmen are laying the keel for a new boat.*** *Wide World*

CUTTING TOOLS THAT NEVER DULL

FASTER than ever before—and with fewer delays—man shapes steel with the Airco oxyacetylene flame. There's no time out for sharpening or regrinding when this modern cutting tool is on the job. Here the Radiagraph—an Airco achievement—is depicted utilizing the oxyacetylene flame to perform a highly specialized cutting operation. So versatile is the standard machine that it does the job speedily, accurately without the aid of special attachments.

New, faster, better ways of making machines, engines, ships, tanks and guns result directly from using this "never dull" production tool. So varied is its application that, in addition to cutting steel swiftly and accurately, the oxyacetylene flame hardens steel to an easily controllable depth, cleans metal surfaces for longer lasting paint jobs, welds metal into a strong, lasting structure. To better acquaint you with the many things that this modern production tool does better we have published "Airco in the News", a pictorial review in book form. Write for a copy.

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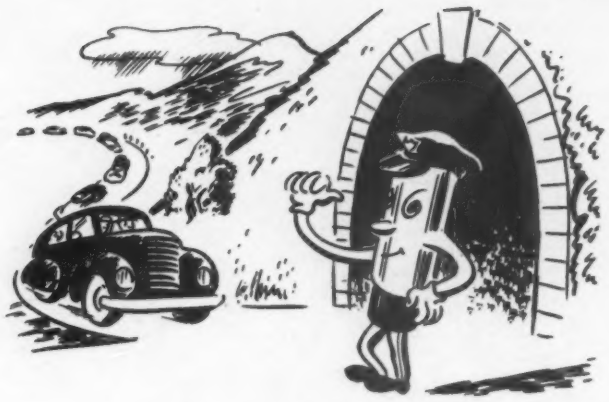
ANYTHING AND EVERYTHING FOR GAS WELDING OR CUTTING AND ARC WELDING

G-E Campus News



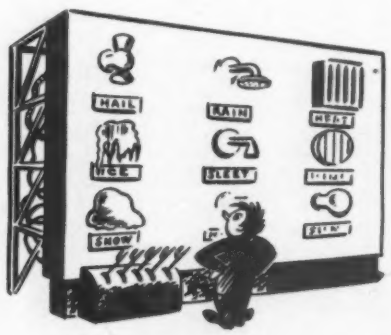
COAST IS CLEAR

FOR three years an automatic traffic control (essentially an electronic device) has been directing motorists through a one-way tunnel that serves as a direct route through a mountain on a Salt Lake County highway in Utah.

The traffic control counts vehicles as they enter and leave the tunnel. If the outgoing count is less than the ingoing, a bell warns a patrolman to go in after the missing car. Thus traffic is kept moving through the tunnel—in one direction at a time.

When the carbon-monoxide content of the air in the tunnel reaches a critical point, another electronic watchman stops traffic and turns on a ventilating fan.

Approximately 600 cars go through the tunnel every 24 hours, but the electronic cop isn't tired yet.



TAKE YOUR CHOICE

THE U.S. Army Air Force can test airplane engines at altitudes of 40,000 feet, where it's 67 below, or at low altitudes over deserts where the temperature soars to 120 F—without taking the ships from the ground.

Testing is done in a laboratory where refrigeration equipment, electric heaters, and air evacuating equipment take over for the elements.

One such lab, for which G.E. is building electrical equipment, will house several test chambers, in each of which engines will be tested under different conditions.

To accomplish this, air will be partly conditioned and then delivered to the various test chambers. At each test chamber the air will be further conditioned to obtain the exact humidity, temperature, and pressure for the particular condition desired. Then the air will be delivered to the engine carburetors.

PIPE DREAM

THE War Emergency Pipeline, largest oil trunk of its kind in the world, will go into operation in January. Extending 531 miles from Longview, Texas to Norris City, Illinois, the "Big-Inch" pipeline (so called because it is 24 inches in diameter) will help alleviate the oil shortage in the East.

G.E. recently shipped, five weeks ahead of schedule, the first two of fifteen 1500-hp motors it is building for the line.

Built of cast iron to conserve steel plate, the motors will be used to drive centrifugal pumps in booster stations along the line. These pumps will keep 1,330,000 barrels of oil flowing at a rate of 4 miles per hour—a delivery rate of 300,000 barrels a day at Norris City.

By June it is expected that the remaining section of the line, 857 miles long, will connect Norris City and the Atlantic seaboard.

GENERAL ELECTRIC

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TECHNICAL NEWS